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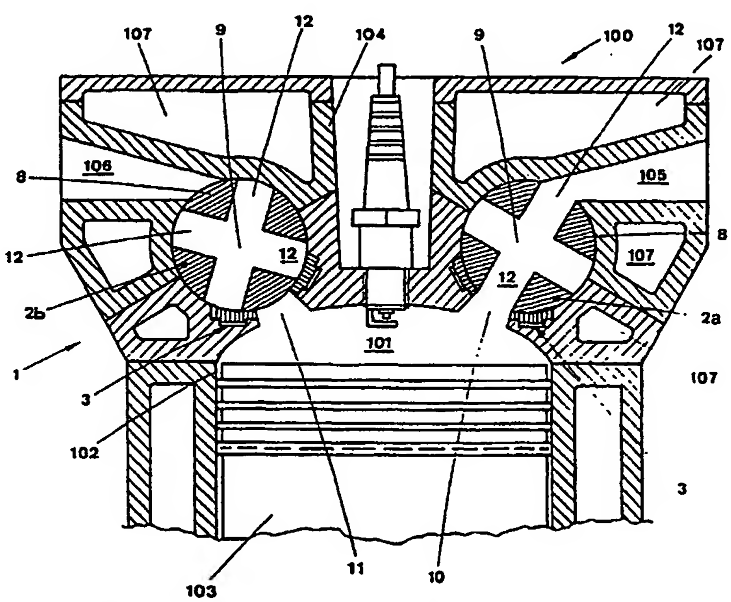

(57) Abstract: This invention relates to rotary valve systems. In its broadest aspect the invention provides an internal combustion engine having a rotary valve system (1), a combustion chamber (101) defined by a cylinder (102), and a piston (103) within the cylinder, the rotary valve system having a rotor (2A, 2B) of cylindrical construction located adjacent the combustion chamber for establishing timed, sequential communicaion between the combustion chamber and a manifold (105, 106), the rotor being characterised in having at least three coplanar ports (11) equi-spaced around the rotor circumference, said ports being interconnected via radially extending passageways (12) interior of the rotor.

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ROTARY VALVE SYSTEMS

TECHNICAL FIELD

The present invention relates to improvements in or associated with valve systems. In particular, the invention relates to improvements in rotary valve timing, control and operation. The inventive improvements have particular, but not exclusive, application to internal combustion engines.

BACKGROUND ART

Rotary valve systems are conceptually well known – it has long been appreciated that significant advantages can be obtained by dispensing with relatively complex and inefficient reciprocating valve arrangements. In this regard, a rotary valve engine does not require the cam shafts, push rods, complex springs and reciprocating valving of a conventional internal combustion engine. In a rotary valve system all of these components are effectively replaced by a rotating valve mechanism. Such systems are exemplified by the disclosures of US Patent Specifications 3989025, 4019487, 4198946, 4370955, 4953527, 4944261, 4989558, 5109814, and 5361739.

A major barrier to rotary valve systems becoming common place is the difficulty in establishing a simple, reliable, cost effective solution to sealing the valve around the combustion chamber inlet and outlet ports. Without such a sealing assembly rotary valve systems fail after only a short period of operation, largely because failure of the seals causes high pressure combustion gases to burn out the bearing assemblies supporting the valve in the cylinder head, and/or high pressure gas erosion of the valve rotor.

It is an object of the present invention to go at least someway towards overcoming the above noted problems with rotary valve systems, or at least to provide the public with a useful choice.

SUMMARY OF THE INVENTION

In a first broad aspect of this there is provided a rotary valve system for use in an internal combustion engine, the engine having a combustion chamber defined by a cylinder, a piston within the cylinder, wherein the rotary valve system haves a rotor of cylindrical construction located adjacent the combustion chamber for establishing timed, sequential communication between the combustion chamber and a manifold, the rotor being characterised in having at least three coplanar ports equi-spaced around the rotor circumference, said ports being interconnected via radially extending passageways interior of the rotor.

In a second broad aspect of this there is provided an internal combustion engine, the engine having a rotary valve system, a combustion chamber defined by a cylinder, and a piston within the cylinder, the rotary valve system having a rotor of cylindrical construction located adjacent the combustion chamber for establishing timed, sequential communication between the combustion chamber and a manifold, the rotor being characterised in having at least three coplanar ports equi-spaced around the rotor circumference, said ports being interconnected via radially extending passageways interior of the rotor.

An advantage of the present invention over prior art rotary valve systems is that, for a four stroke combustion cycle, the rotor is required to rotate at a speed significantly less than the rotational speed of the engine, namely:

$$R_V = \frac{R_E}{2xN}$$

Where:

R_V is the rotational velocity of the rotor.

R_E is the rotational velocity of the engine.

N is the number of coplanar ports equi-spaced around the circumference of the rotor.

Such a reduction in speed has an important impact on the nature and sophistication of the sealing assembly required to ensure successful operation. In particular because more commonplace sealing technologies may be used, as wear issues are less significant. Further, greater contact surface area can be provided and maintained as friction losses and heat building up are much less significant at lower relative engagement speeds.

Preferably the rotor of the rotary valve system has at least four interconnected, coplanar, ports equi-spaced around the rotor circumference.

Desirably the rotor of the rotary valve system has at least six interconnected, coplanar, ports equi-spaced around the rotor circumference.

Optionally the rotor of the rotary valve system can have eight interconnected, coplanar, ports equi-spaced around the rotor circumference.

Preferably the rotary valve system further includes a pair of rotors, each of which is of substantially elongate cylindrical construction, a first said rotor being located adjacent the said combustion chamber for establishing timed, sequential communication between the said combustion chamber and an inlet manifold and a second said rotor being located adjacent the said combustion chamber for establishing timed, sequential communication between the said combustion chamber and an outlet manifold.

Desirably the first and second rotors are of different diameter.

Optionally the ports and interconnecting passageways of each said rotor are of circular cross section. Alternatively the ports and interconnecting passageways of each said rotor can be shaped to extend across substantially the full cord described by the rotor's engagement with the combustion chamber.

Preferably the rotary valve system further includes valve seal assembly means surrounding and sealing the area of engagement between each rotor and the combustion chamber.

Preferably each said seal assembly means includes a side sealing bearing and ring seals, and desirably each said side seal is configured and arranged to locate adjacent the area of engagement between the combustion chamber and the rotor, and to be held in bearing engagement with the corresponding rotor by way of spring biasing means.

Desirably the spring biasing means is in the form of a spring steel member.

Advantageously a said ring seal is mounted on the respective rotor at either end of the said side seal, and is configured and arranged to both prevent the escape of high pressure combustion gases, as well as entry of unwanted lubricant or the like into the combustion chamber. Preferably each said ring seal is located in position in a corresponding groove in the rotor.

Preferably the rotary valve system further includes a rotor rotational velocity controlling means which can be used to control the rotational velocity of each said rotor relative to the engine rotational velocity.

Desirably the rotor rotational velocity controlling means is configured and arranged to continuously vary the rotational velocity of each said rotor relative to the engine rotational velocity.

Preferably the rotational velocity of each said rotor is varied sinusoidally, and the number of sinusoidal rotor variation cycles within a single rotation of the rotor corresponds to the number of interconnected, coplanar, ports equi-spaced around the rotor circumference.

Alternatively the rotor rotational velocity controlling means controls the rotor rotational velocity in a stepwise fashion.

Desirably the rotor rotational velocity controlling means includes a principal driver assembly and a sinusoidal actuator.

Conveniently the principal driver assembly can include a power take up gear, a driver plate, three planet gears, a ring gear, and an actuating lug, the principal driver assembly being configured and arranged such that the ring gear is rotatably mounted on locating bearings which fix the position of the ring gear in all axis and planes except its rotational axis, and the actuating lug extending radially outwardly from the ring gear, with the three planet gears being mounted off the driver plate which is connected to one side of the power take up gear, the three planet gears being mounted at equal spacing from one another, and the rotational axis of the driver plate, such that each planet gear is free to rotate about its own rotational axis, with the ring gear surrounding and engaging each of the three planet gears, and an end of the rotor being captured between and driven by the three planet gears.

Preferably the sinusoidal actuator includes a driving wheel and a connecting member such that the connecting member is pin jointed between the said actuating lug and the periphery of the driving wheel.

Preferably the internal combustion engine further includes a valve timing adjustment means, a valve system driving means, a valve system driven means, and connecting means to communicate the driving force from the valve system driving means to the valve system driven means, the valve timing adjustment means including tensioning means acting on the connecting means to adjust the relative engagement between the valve system driving means and the valve system driven means.

Desirably the connecting means is a belt or chain connecting a pair of driven pulleys or gears, one each mounted at one end of each said rotor, said chain or belt being driven by a gear arrangement from the engine crankshaft.

Preferably the valve timing adjustment means further includes a first plate slideably mounted from the front of the engine block, a second plate pivotably mounted on the first plate, tensioner gears rotatably mounted on the second plate, a first cam to drive the first plate vertically up or down, and a second cam to rotate the second plate with respect to the first plate.

Conveniently the valve timing adjustment means can be configured and arranged so that one of the tensioner gears engages the chain or belt between the driven gears, another of the tensioner gears engages the chain or belt between a first of the driven gears and a gear arrangement driven from the crank shaft, and a third of the tensioner gears engages the chain or belt between the second of the driven gears and the said gear arrangement driven from the crank shaft.

Desirably the shaft of the third tensioner gear serves to rotatably mount the second plate to the first plate, and rotation of the second plate is actuated by operation of the second cam, which is itself mounted of the first plate.

Preferably the first plate is slidably confined between guides, which ensure that the first plate is only able to travel vertically and parallel to the guides.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1: shows a sectional end elevation of an internal combustion engine cylinder head incorporating a rotary valve system according to the present invention;

Figure 2: shows an exploded perspective view of the seal assembly of the rotary valve system of figure 1;

Figure 3: shows a side elevation of the rotary valve rotor shaft of the rotary valve system of figure 1;

Figure 4: shows a sectional side elevation of the valve rotor shaft motion control mechanism of the rotary valve system of figure 1;

Figure 5: shows an end elevation of the valve rotor shaft motion control mechanism of the rotary valve system of figure 1;

Figure 6: shows a graph of the rotational velocity of the rotary valve rotor shaft of figure 3 when under the control of the motion control mechanism of figures 4 & 5;

Figure 7: shows an end elevation of a valve timing control mechanism according to the present invention for use with the internal combustion engine and valve system of figure 1; and,

Figure 8: shows an end elevation of the valve timing control mechanism of figure 7 with the timing mechanism controllers in different positions.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to the drawings, in a preferred embodiment the invention provides a rotary valve system, as generally indicated at 1, for use in an internal combustion engine, as generally indicated at 100. Referring more specifically to figure 1, the engine 100 has a combustion chamber 101 (only one is shown) defined by a cylinder 102, a piston 103 within the cylinder 102, and a cylinder head 104.

The rotary valve system 1 includes a pair of rotary valve rotor shafts 2A, 2B, each of substantially elongate cylindrical construction, and being located adjacent the combustion chamber 101 for establishing timed, sequential communication between the combustion chamber 101 and an inlet manifold 105 (or, as the case may be, an outlet manifold 106).

In addition to the rotor shafts 2A, 2B the system 1 includes a plurality of associated valve seal assemblies 3, a valve rotor shaft motion control mechanism 6 and a valve timing control mechanism 7.

It should be understood that purely for the sake of clarity the rotary valve system 1 is depicted in the drawings, and is so described, as mounted on a four cylinder, in-line, internal combustion engine 100. However, the system 1 may be used on any engine configuration, from a single cylinder arrangement to any number of cylinders. Further, the cylinder orientation, whether, for example, in-line, horizontally opposed, "V", or radial has no bearing on application of the system. Clearly, however, in each instance where all of the cylinders cannot be serviced by a pair of valve rotor shafts 2A, 2B the system must be duplicated.

Referring more specifically to figures 1 and 3, each valve rotor shaft 2A, 2B comprises an elongate shaft member 8 of sufficient length to span the spread of cylinders which it services, together with an allowance at either end for bearing mounts and location.

Radiating outwardly from the shaft core 9, at positions along the shaft member 8 corresponding to inlet ports 11 (or, if the valve rotor shaft 2A, 2B is on the exhaust side, outlet ports 11) into (or out of as appropriate) the combustion chambers 101, are provided passageways 12. In the preferred embodiment four passageways 12 are illustrated, but it is within the scope of the invention for six, eight or more passageways to be provided – the defining factors determining the number of passageways 12 are the diameters of the shaft members 8 and the cross sectional area requirements for the passageways 12 to achieve adequate porting. In that regard, it is also within the scope of the present invention for the inlet and outlet valve rotor shafts 2A, 2B to be different diameters.

The shaft members 8 are mounted in the cylinder head 104 in a manner well known in the art. Cooling passages 107 can be provided circulating water or oil coolant, again as is well known in the art.

Unlike traditional reciprocating type valve systems, the passageways 12 and ports 10, 11 need not be circular in shape. Indeed, to maximise the advantage gained from utilising a rotary valve system the passageways 12 and ports 10, 11 should be as large as possible –

extending across, as far as is practicable, the full cord described by the shaft members 8 across the combustion chamber 101.

Turning now also to figure 2, to ensure a long operating life it is critical to establish adequate sealing between the shaft members 8 and the respective ports 10, 11 into the combustion chamber 101. A central feature of the present invention which makes this simpler is that the rotational velocity of the shaft members 8 is, in the embodiment described and illustrated, only 1/8th the engine rotational velocity. Thus, for example, at normal engine operational speeds of, say, 3200 revolutions per minute, the shaft members 8 rotate at only 400 revolutions per minute. With such relatively low rotational velocities the frictional losses, and thus heat generation, are commensurately lower. This allows for greater bearing area between seals and the shaft members 8, the use of more common place bearing materials, and thus significantly cheaper and more effective sealing mechanisms.

In the preferred embodiment the seal assembly 3 comprises a side sealing bearing 13 and ring seals 14. The side seal 13 is configured and arranged to locate in the cylinder head 104 about the port 10 (or 11 as appropriate), and to be held in bearing engagement with the corresponding shaft member 8 by way of spring biasing means, preferably in the form of spring steel members 15. The ring seals 14 are mounted on the respective shaft member 8 at either end of the side seal 13, and serve to both prevent the escape of high pressure combustion gases, as well as entry of unwanted lubricant or the like into the combustion chamber 101. Preferably the ring seals 14 are located in position in grooves (not shown) in the shaft members 8, and corresponding grooves (not shown) in the cylinder head 104.

One problem identified with simply increasing the number of passageways 12 to reduce the shaft member 8's rotational velocity is that with increased passageway numbers it becomes increasingly difficult to open and close each passageway 12 with respect to the port 10, 11 within the desirable operating limits.

Accordingly, the preferred embodiment includes a valve rotor shaft motion control mechanism 6. This mechanism 6 varies the rotational speed of each shaft member 8 sinusoidally, thereby achieving maximum full open time at the appropriate time, and complete closure at the appropriate time.

Referring to figures 4 and 5, the mechanism 6 comprises a principal driver assembly 16, and a sinusoidal actuator 17.

The principal driver assembly 16 involves a power take up gear 18, extending from one side of which is a driver plate 19. Three planet gears 20 are mounted from the driver plate 19 at equal spacing from one another, and the rotational axis of the driver plate 19.

Each gear 20 is free to rotate about its own rotational axis 21. A ring gear 22 surrounds, gearingly engages, and interconnects the three planet gears 20. An end 23 of the shaft member 8 is gearingly captured between and driven by the three planet gears 20.

The ring gear 22 is rotatably mounted on locating bearings 24 which fix the position of the ring gear 22 in all axis and planes except its rotational axis.

A lug 25 extends radially outwardly from the ring gear 22.

The sinusoidal actuator 17 comprises a driving wheel 26. A connecting member 27 is pin jointed to each of the lug 25 and the periphery 28 of the wheel 26.

In use constant velocity rotation of the gear 18 produces, through the plate 19, and gears 20, 22, constant velocity rotation in the shaft member 8.

Rotation of the wheel 26 causes the connecting member 27 to drive the ring gear 22 first in one rotational direction, and then the reverse. The rotation velocity introduced into the ring gear 22 by the wheel 26 is thus cyclically sinusoidal in nature.

If the gear 18 is held fixed the ring gear 22 will transfer the sinusoidal rotational velocity introduced by the wheel 26 to the shaft member 8. Further, if the gear 18 is rotated at constant velocity the wheel 26 will introduce a sinusoidal velocity overlay into the rotational motion of the shaft member 8. This can be seen in the graph illustrated as figure 6.

The number of sinusoidal cycles introduced per rotation of the shaft member 8 is determined by he number of rotations of the wheel 26 per rotation of the gear 18, and the gearing ratios between the gears 18, 20 and 22. The number of cycles must correspond to the number of passageways 12 per valve position. Ideally, there should be twice as many cycles as passageways 12.

The magnitude of the sinusoidal influence on the rotational velocity of the shaft member 8 at any moment in time is a direct function of the radial displacement of the connecting member 27 pin joint from the rotational axis of the wheel 26. Referring to figure 6, it will thus be appreciated that by selecting an appropriate wheel 26 size it is possible to momentarily stop, or even reverse, rotation of the shaft member 8.

Accordingly, by careful design it is possible to hold a passageway 12 substantially fully open across a port 10, 11 for a desired period, and then fully closed for a correspondingly similar period.

The preferred embodiment also includes a valve timing control mechanism 7. Figures 7 and 8 illustrate the front end of the engine 100. The two gears 18 illustrated correspond one each to rotary valve rotor shafts 2A, 2B, (shaft members 8) being for inlet valves and outlet valves respectively.

The gears 18 are driven, via a chain 28, by a gear arrangement (not shown) from the engine crankshaft (not shown).

The mechanism 7 includes a plate 29 which is slideably mounted from the front of the engine block 108, a plate 30 which is pivotably mounted on the plate 29, gears 31, 32,33

which are rotatably mounted on the plate 30, a cam 34 to drive the plate 29 vertically up or down, and a cam 35 to rotate the plate 30 with respect to the plate 29. Also included are control mechanisms (not shown) to actuate the cams 34, 35.

The mechanism 7 is configured and arranged so that the gear 31 engages the chain 28 between the gears 18, causing the chain to pass over each said gear 18, down and then beneath the gear 31.

The gear 32 engages the chain 28 between a first of the gears 18 and the gear arrangement driven from the crank shaft. The gear 32 pulls the chain 28 inwardly, towards the gear 31.

The gear 33 engages the chain 28 between the second of the gears 18 and the gear arrangement driven from the crank shaft. The gear 33 also pulls the chain 28 inwardly, towards the gear 31. The shaft 36 on which the gear 33 rotates also serves to rotatably mount the plate 30 to the plate 29. Rotation is achieved by actuation of the cam 35, which is itself mounted on the plate 29. Under the action of the cam 35 the plate 30 rotates about the shaft 36.

The plate 29 is slidably confined between guides 37. The guides 37 ensure that the plate 29 is only able to travel vertically and parallel to the guides 37. The cam 34 is mounted on the engine block 108, and operates to drive the plate 29 upwardly or downwardly depending on its present position.

In operation, and as will be apparent to a person skilled in the art, drawing the plate 29 up or down has the effect of varying the relative valve positions. Rotating the plate 30 has the effect of advancing or retarding one of the valves.

It is thus seen that the present invention provides a simple and effective advancement in the art.

Where in the foregoing description reference has been made to integers or components having known equivalents then such equivalents are herein incorporated as if individually set forth.

Although this invention has been described by way of example it is to be appreciated that improvements and/or modifications may be made thereto without departing from the scope or spirit of the invention.

Wherein the foregoing reference has been made to integers or components having known equivalents, then such equivalents are herein incorporated as if individually set forth.

Accordingly, it will be appreciated that changes may be made to the above described embodiments of the invention without departing from the principles taught herein.

Additional advantages of the present invention will become apparent for those skilled in the art after considering the principles in particular form as discussed and illustrated. Thus, it will be understood that the invention is not limited to the particular embodiments described or illustrated, but is intended to cover all alterations or modifications which are within the scope of the appended claims.

CLAIMS

1. A rotary valve system for use in an internal combustion engine, the engine having a combustion chamber defined by a cylinder, a piston within the cylinder, wherein the rotary valve system haves a rotor of cylindrical construction located adjacent the combustion chamber for establishing timed, sequential communication between the combustion chamber and a manifold, the rotor being characterised in having at least three coplanar ports equi-spaced around the rotor circumference, said ports being interconnected via radially extending passageways interior of the rotor.

2. An internal combustion engine, the engine having a rotary valve system, a combustion chamber defined by a cylinder, and a piston within the cylinder, the rotary valve system having a rotor of cylindrical construction located adjacent the combustion chamber for establishing timed, sequential communication between the combustion chamber and a manifold, the rotor being characterised in having at least three coplanar ports equi-spaced around the rotor circumference, said ports being interconnected via radially extending passageways interior of the rotor.

3. An internal combustion engine according to claim 2 wherein the rotor of the rotary valve system has at least four interconnected, coplanar, ports equi-spaced around the rotor circumference.

4. An internal combustion engine according to claim 2 wherein the rotor of the rotary valve system has at least six interconnected, coplanar, ports equi-spaced around the rotor circumference.

5. An internal combustion engine according to claim 2 wherein the rotor of the rotary valve system has eight interconnected, coplanar, ports equi-spaced around the rotor circumference.

6. An internal combustion engine according to any one claims 2 to 5 wherein the rotary valve system further includes a pair of rotors, each of which is of substantially elongate cylindrical construction, a first said rotor being located adjacent the said combustion chamber for establishing timed, sequential communication between the said combustion chamber and an inlet manifold and a second said rotor being located adjacent the said combustion chamber for establishing timed, sequential communication between the said combustion chamber and an outlet manifold.

7. An internal combustion engine according to any one claims 2 to 5 wherein the first and second rotors are of different diameter.

8. An internal combustion engine according to any one claims 2 to 7 wherein the ports and interconnecting passageways of each said rotor are of circular cross section.

9. An internal combustion engine according to any one claims 2 to 7 wherein the ports and interconnecting passageways of each said rotor are shaped to extend across substantially the full cord described by the rotor's engagement with the combustion chamber.

10. An internal combustion engine according to any one claims 2 to 9 wherein the rotary valve system further includes valve seal assembly means surrounding and sealing the area of engagement between each rotor and the combustion chamber.

11. An internal combustion engine according to claim 10 wherein each said seal assembly means includes a side sealing bearing and ring seals.

12. An internal combustion engine according to claim 11 wherein each said side seal is configured and arranged to locate adjacent the area of engagement

between the combustion chamber and the rotor, and to be held in bearing engagement with the corresponding rotor by way of spring biasing means.

13. An internal combustion engine according to claim 12 wherein the spring biasing means is in the form of a spring steel member.

14. An internal combustion engine according to any one of claims 11 to 13 wherein a said ring seal is mounted on the respective rotor at either end of the said side seal, and is configured and arranged to both prevent the escape of high pressure combustion gases, as well as entry of unwanted lubricant or the like into the combustion chamber.

15. An internal combustion engine according to any one of claims 11 to 14 wherein each said ring seal is located in position in a corresponding groove in the rotor.

16. An internal combustion engine according to any one of claims 2 to 15 wherein the rotary valve system further includes a rotor rotational velocity controlling means which can be used to control the rotational velocity of each said rotor relative to the engine rotational velocity.

17. An internal combustion engine according to claim 16 wherein the rotor rotational velocity controlling means is configured and arranged to continuously vary the rotational velocity of each said rotor relative to the engine rotational velocity.

18. An internal combustion engine according to claim 17 wherein the rotational velocity of each said rotor is varied sinusoidally.

19. An internal combustion engine according to claim 18 wherein the number of sinusoidal rotor variation cycles within a single rotation of the rotor

corresponds to the number of interconnected, coplanar, ports equi-spaced around the rotor circumference.

20. An internal combustion engine according to claim 16 wherein the rotor rotational velocity controlling means controls the rotor rotational velocity in a stepwise fashion.

21. An internal combustion engine according to claim 16 wherein the rotor rotational velocity controlling means includes a principal driver assembly and a sinusoidal actuator.

22. An internal combustion engine according to claim 21 wherein the principal driver assembly includes a power take up gear, a driver plate, three planet gears, a ring gear, and an actuating lug, the principal driver assembly being configured and arranged such that the ring gear is rotatably mounted on locating bearings which fix the position of the ring gear in all axis and planes except its rotational axis, and the actuating lug extending radially outwardly from the ring gear, with the three planet gears being mounted off the driver plate which is connected to one side of the power take up gear, the three planet gears being mounted at equal spacing from one another, and the rotational axis of the driver plate, such that each planet gear is free to rotate about its own rotational axis, with the ring gear surrounding and engaging each of the three planet gears, and an end of the rotor being captured between and driven by the three planet gears.

23. An internal combustion engine according to claim 22 wherein the sinusoidal actuator includes a driving wheel and a connecting member such that the connecting member is pin jointed between the said actuating lug and the periphery of the driving wheel.

24. An internal combustion engine according to claim 6 further including a valve timing adjustment means, a valve system driving means, a valve system

driven means, and connecting means to communicate the driving force from the valve system driving means to the valve system driven means, the valve timing adjustment means including tensioning means acting on the connecting means to adjust the relative engagement between the valve system driving means and the valve system driven means.

25. An internal combustion engine according to claim 24 wherein the connecting means is a belt or chain connecting a pair of driven pulleys or gears, one each mounted at one end of each said rotor, said chain or belt being driven by a gear arrangement from the engine crankshaft.

26. An internal combustion engine according to claim 24 wherein the valve timing adjustment means further includes a first plate slideably mounted from the front of the engine block, a second plate pivotably mounted on the first plate, tensioner gears rotatably mounted on the second plate, a first cam to drive the first plate vertically up or down, and a second cam to rotate the second plate with respect to the first plate.

27. An internal combustion engine according to claim 26 wherein the valve timing adjustment means is configured and arranged so that one of the tensioner gears engages the chain or belt between the driven gears, another of the tensioner gears engages the chain or belt between a first of the driven gears and a gear arrangement driven from the crank shaft, and a third of the tensioner gears engages the chain or belt between the second of the driven gears and the said gear arrangement driven from the crank shaft.

28. An internal combustion engine according to claim 27 wherein the shaft of the third tensioner gear serves to rotatably mount the second plate to the first plate, and rotation of the second plate is actuated by operation of the second cam, which is itself mounted of the first plate.

29. An internal combustion engine according to claim 28 wherein the first plate is slidably confined between guides, which ensure that the first plate is only able to travel vertically and parallel to the guides.

30. An internal combustion engine substantially as herein described or exemplified with reference to the accompanying drawings.

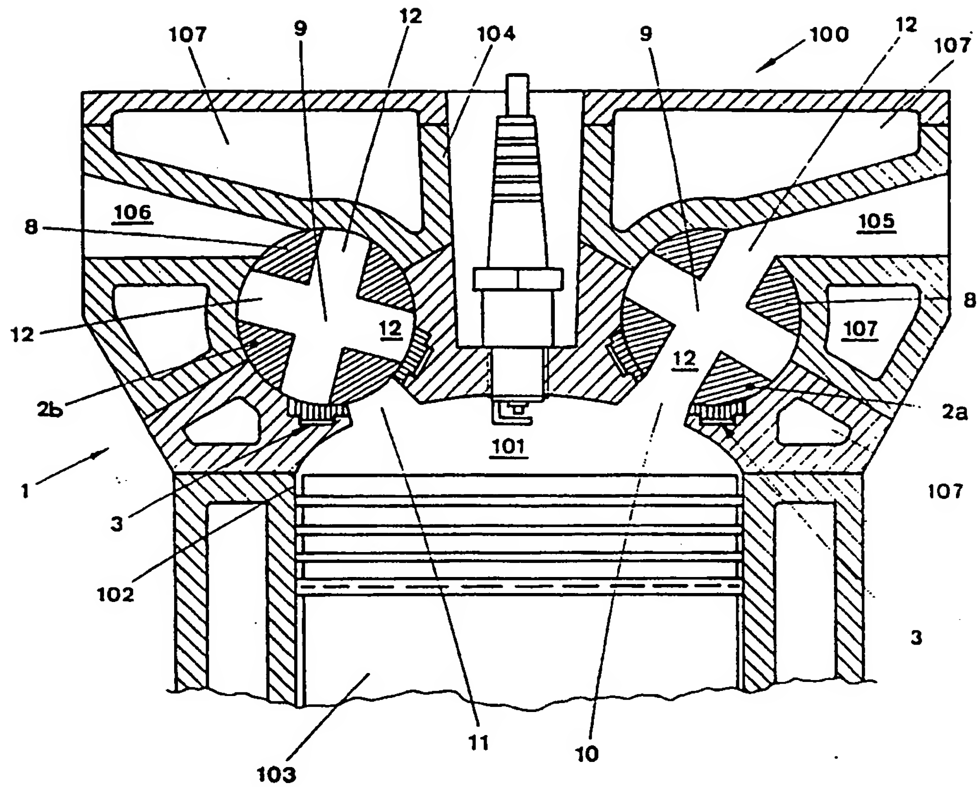

Figure 1

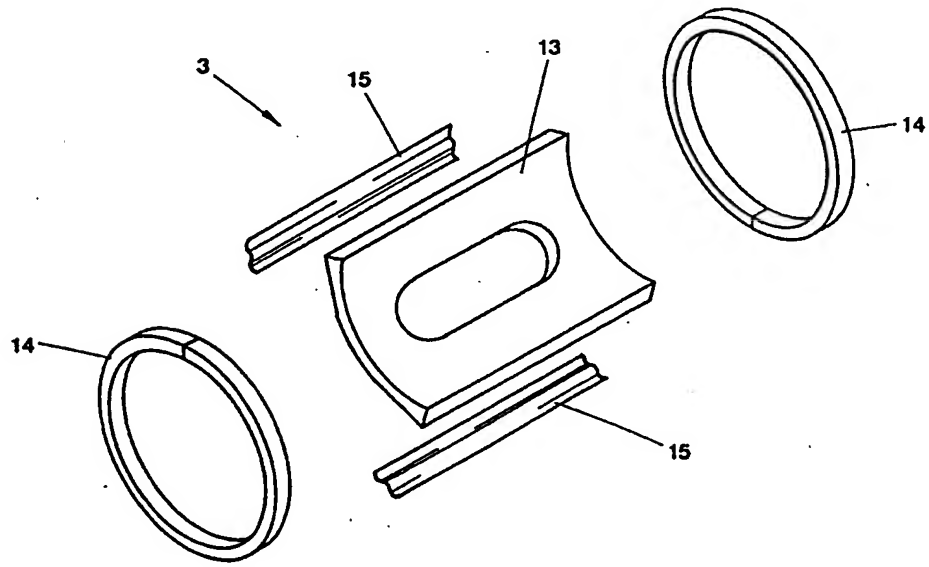

Figure 2

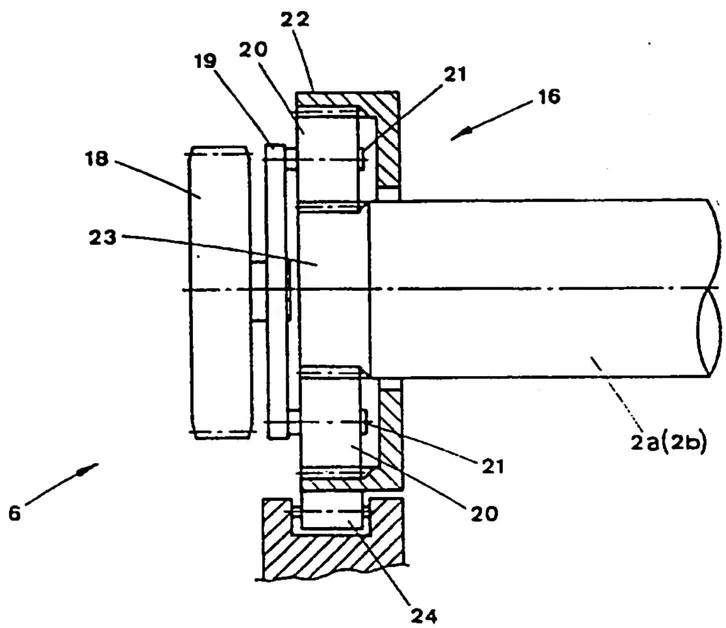

Figure 4

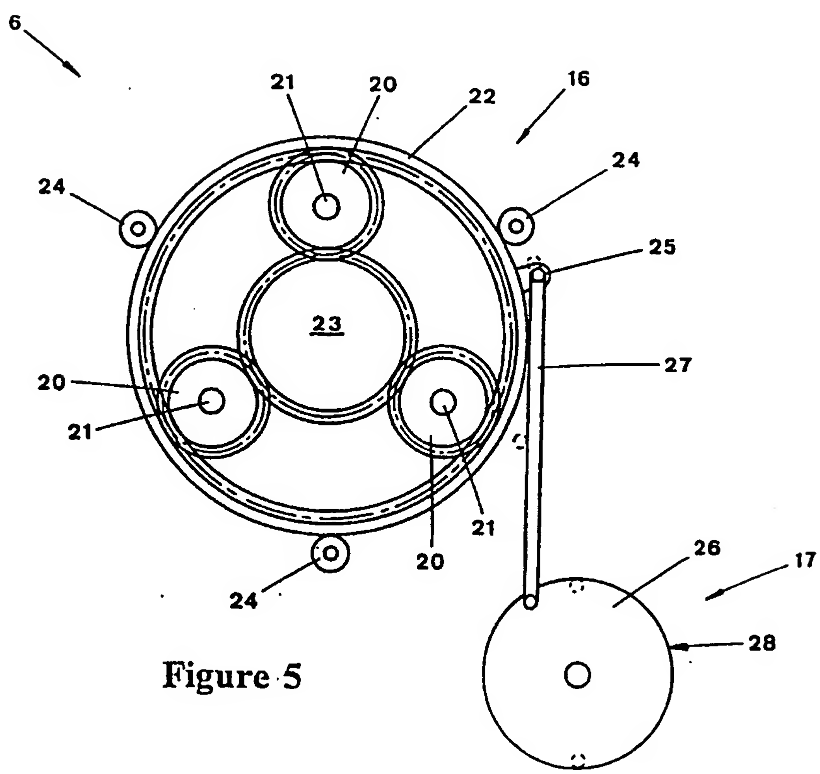

Figure 5

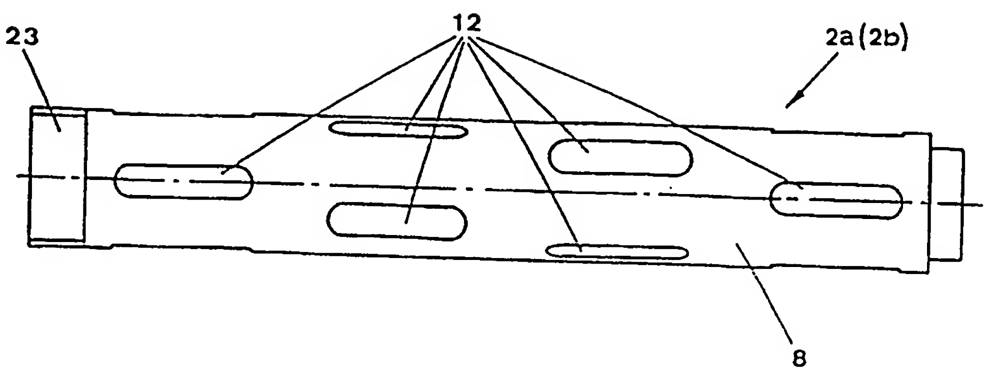

Figure 3

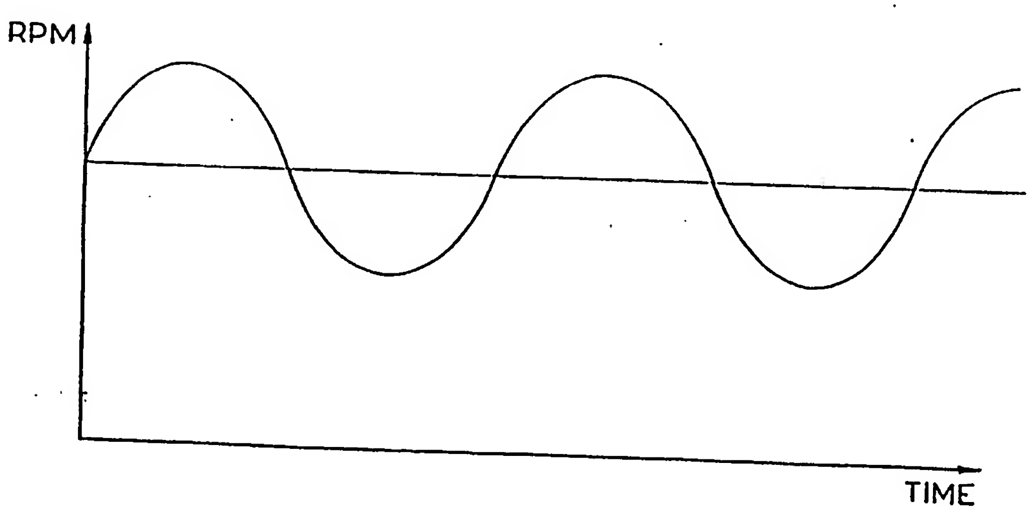

Figure 6

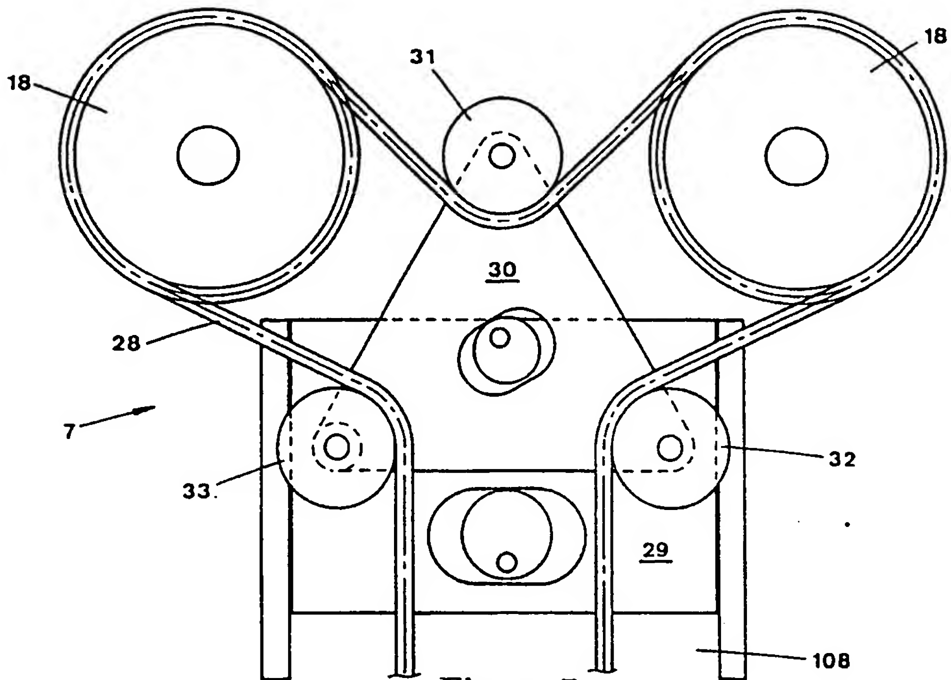

Figure 7

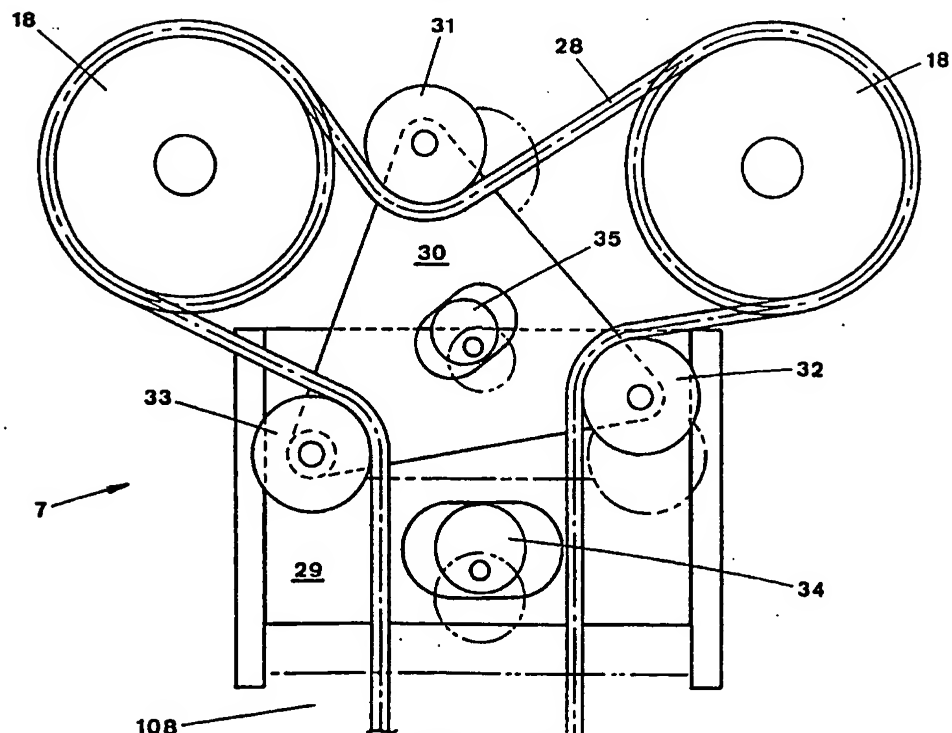

Figure 8

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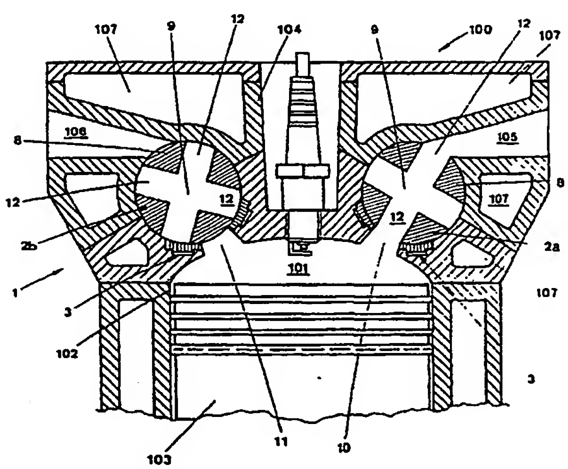
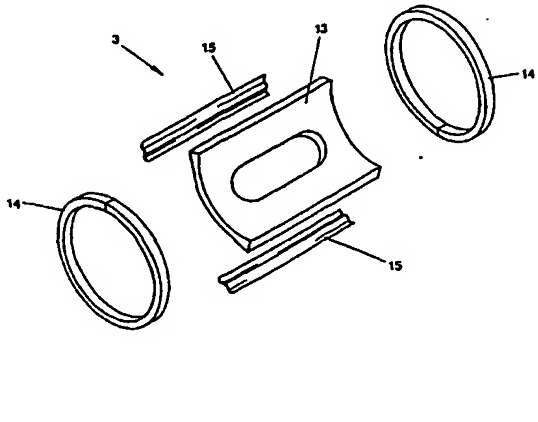
[Continued on next page]

(54) Title: ROTARY VALVE SYSTEMS



(57) Abstract: This invention relates to rotary valve systems. In its broadest aspect the invention provides an internal combustion engine having a rotary valve system (1), a combustion chamber (101) defined by a cylinder (102), and a piston (103) within the cylinder, the rotary valve system having a rotor (2A, 2B) of cylindrical construction located adjacent the combustion chamber for establishing timed, sequential communicaion between the combustion chamber and a manifold (105, 106), the rotor being characterised in having at least three coplanar ports (11) equi-spaced around the rotor circumference, said ports being interconnected via radially extending passageways (12) interior of the rotor.



WO 00/71858 A3

Published:
— *With international search report.*
— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

(88) Date of publication of the international search report: 8 February 2001

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/NZ00/00080

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : F01L 7/02
US CL : 123/190.2
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 123/190.2,190.1,190.17,80BA,190.8,190.11

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, 1,347,978, A (WEHR) 27 July 1920, col. 2, lines 75-105.	1,2
Y		6,24,25
Y	US 4,019,487 A (GUENTHER) 26 April 1977, col. 2, lines 55-68; col. 3, lines 1-37.	6
Y	US 1,135,719 A (RITTER) 13 April 1915, col. 3, lines 11-22.	24,25
A	US 1,782,389 A (RAUHA, JR. ET AL) 18 November 1930, see entire document.	3-5,7,26-29

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search	Date of mailing of the international search report
14 NOVEMBER 2000	28 NOV 2000

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INTERNATIONAL SEARCH REPORT

International Application No.
PCT/NZ00/00080

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. [X] Claims Nos.: 30
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

   Claim 30 is indefinite because it fails to point out what is included or excluded by the claim language. This claim is an omnibus type claim.

3. [X] Claims Nos.: 8-23
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet(1)) (July 1998)★